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ABSTRACT

A brief review is presented of the characteristics of four maxicalculators (HP 9830, Wang 2200, IBM 5100, MCM/700) and two minicomputers (Classic, Altair 8800). The HP 9830 and the Wang 2200 are thought to be the best adapted to serve entire schools and their unique properties are discussed. Some criteria of what should be taken into account in the interaction between the user and the machine are briefly mentioned. (DAG)

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MAXICALCULATORS FOR THE WHOLE SCHOOL

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Preface

Maxicalculators (and their peripherals) are one type of small computer system. Even though these systems are small, the choice among them is still not a simple matter when the maxicalculators are to be used with the greatest effectiveness in educational applications, for then they must serve a great variety of students, teachers and administrators and in many different modes of operation.

Our discussion of the choice among maxicalculators concerns two aspects:

a) the capabilities of maxicalculators for the whole school;

b) an example of a detailed comparison between two maxicalculators.

The first aspect is covered in ISEAC paper Number 5 and the second in ISEAC Number 6.

These papers were based on a report by Richard Doring which was written in November 1975 for the Secondary Education course, "Computers for the Whole School" using the data on equipment, costs and capabilities that were then available to us. We believe that the criteria of choice he developed will still retain their validity even though these data are changed by the appearance of new or improved equipment. Nothing in the two papers is meant to imply recommendation by the authors or the Department of Secondary Education for purchase of any calculator or peripheral. The purpose of the papers is rather to discuss and illustrate the mechanics of choosing this computer equipment.

Other aspects of the choice among maxicalculators should be mentioned although they will not be discussed in the two papers. The relation between specific educational applications of maxicalculators and the capabilities of maxicalculators is an important and neglected aspect, but one that is difficult to treat with any generality. The quality of courseware and external software* supplied by the manufacturers clearly should affect the choice among maxi-calculators. (Much of the courseware should be developed by each user school for its own specific needs.) Other considerations are the reliability of the calculator and its peripherals, the quality of maintenance service and the compatibility of the calculator with new peripherals and new modifications of the calculator.

Bruce Hicks
ISEAC Editor

*We use this term to designate the programs on cassette tapes as distinguished from those built into the calculators and their read-only memories.

ISEAC Number 5

MAXICALCULATORS FOR THE WHOLE SCHOOL

Richard Doring[a] and Bruce Hicks[b]

I. Introduction

Computers for the whole school are supposed to serve the whole school community. This means that each member of the school is a potential user of the computer. But in fact the majority of school teachers and students have not yet been exposed to the service that a computer can provide. This is certainly due to a variety of reasons, but one reason may be that, in the eyes of many people, the medium size computers and minicomputers are still surrounded by some mystery that can be revealed only by a few very talented and very ambitious individuals.

This is not true for the new, so-called maxicalculators because they allow for very easy interaction between user and computer.

But can these maxicalculators be used by many different people in a school? Can they be used as computers for the whole school?

2. Small computer systems

In the last few years several new types of computers have appeared on the market. One can read about super-calculators, maxicalculators, programmable calculators, and even about a calcuputer (see (1)), but all these labels describe essentially the same kind of machine.

Each of these is distinct from the well-known minicomputers. But the properties of these calculators are almost identical:

-portable, compact single-user computer
-immediate execution of arithmetic computations
-programmable in BASIC or APL (hard-wired)
-teletype-like keyboard with special purpose keys
-magnetic tape secondary memory (cassette or cartridge)
-optical display
-priced below $10,000 (without additional peripherals)
-designed for adding on many peripherals that extend software, input-output, data communication and other capabilities.

A computer with these properties will be called a maxicalculator in this paper. Four maxicalculators can be purchased at this time:

-the Hewlett-Packard Model 9830 (HP9830)
-the Wang System 2200 (Wang 2200)
-the IBM 5100 Portable Computer (IBM 5100)
-the Micro Computer Machines MCM/700

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There are at least two minicomputers that have somewhat similar properties:

-Digital's Classic
-the Altair 8800 from MITS

2.1 Maxicalculators

2.1.1 HP9830

The HP9830 has been available since 1973. It is a general purpose calculator, programmable in an advanced version of the language BASIC (see reference (2)). A minimum configuration comprises

-a keyboard including a typewriter-keyset, desk-top calculator keys, special function keys and control keys;
-a tape cassette, which allows sequential read/write;
-a single line plasma display (32 characters);
-a central processing unit (CPU) with a read/write memory of 3520 8-bit bytes (1760 words).

These features are assembled in one very compact housing which is easily portable. The user can select from a variety of read-only-memory (ROM) plug-in blocks for increased computational capability or peripheral control or both. Many peripherals are available, including a plotter, a thermal printer and a marked/punched card reader.

The HP9830 is well-designed for the new user to learn to operate it in a very short time. This was observed, for example, when education students were getting acquainted with the HP9830.

2.1.2 Wang 2200

The Wang 2200 appeared on the market late in 1973. This maxicalculator is programmable in an advanced version of BASIC (see reference (3)). A minimum 2200 system includes:

-a keyboard which consists of a typewriter-keyset, calculator keys, special function keys and control keys;
-a tape cassette with sequential read/write;
-a fast CRT* display of 16 lines of 64 alpha-numeric characters each (9" diagonal);
-a central processing unit with about 1700 words of read/write memory.

The terminal and the CPU are in different housings. They are easily portable.

ROM's for additional input/output and for matrix operations are available. Wang offers a large variety of peripherals which include inexpensive disk drives, several printers, and marked/punched card readers.

The Wang 2200 requires some understanding of the functions of a computer and its peripherals, if a variety of input-output devices are to be used. It is less easy to learn to use than the HP9830 but more powerful in some ways, especially in its display capabilities.

*"CRT" stands for cathode ray tube, which provides a display somewhat similar to a TV screen.

2.1.3 IBM 5100

The IBM 5100 appeared in public in 1975. It is a portable computer which is programmable in BASIC and/or APL. It is complete in a very compact housing with:

-a keyboard (typewriter-keyset, also BASIC and APL notation, calculator keys, and control keys);
-a fast tape cartridge drive (200K* bytes of storage);
-a minature CRT screen (4" wide) capable of displaying 16 lines of 64 characters (1,024 total);
-a CPU of 16K bytes memory (4K are reserved for system control, up to 8K are needed for the languages)--about 4K bytes of workspace.

This configuration (with one language) is sold for $8,900. The only additional peripherals are a TV display, a printer and an auxiliary tape unit. Batch input via cards or cassette tapes is not possible.

Experience during a demonstration of the IBM 5100 has shown that this maxicalculator is very effective for users who are familiar with a terminal, but it is not easy to handle for beginners.

As IBM does not provide a mark sense card reader for the IBM 5100, which seems to be a necessity for its usefulness in the whole school, the IBM 5100 is not discussed in detail in this paper. But it is strongly suggested that the IBM 5100 be considered for a future evaluation concerning it's educational applications.

2.1.4 MCM/700

This maxicalculator was introduced in 1975. Like the IBM machine it is very compact and portable. It provides an advanced version of the language APL. It's resident operating system provides a virtual memory and controls a general purpose interface. This maxicalculator includes:

-an IBM compatible keyboard with full APL notation and control keys;
-a one-line plasma display (32 characters)
-a CPU with 4K bytes of workspace.

This configuration is sold for $7200. Additional peripherals are a communications subsystem, printer/plotters, a mark or punch card reader, acoustic coupler, a second magnetic cassette tape drive, a dual diskette unit, a video display and an additional 4K bytes of workspace.

The MCM/700, because of its full APL, and its operating system, interface and communication capabilities appears to be the most powerful and versatile of the maxicalculators. It should be noted that APL has often been used with great success in educational applications, in secondary schools and universities as well as for scientific and business applications. Among secondary schools involved in instructional applications of computers, however, only about 1% use APL whereas some 60% use BASIC (4).

The authors have not yet had an opportunity to use the MCM/700 so it is not discussed further in this paper.

*K = 1024.

2.2 Minicomputers

The Classic from Digital Equipment Co. and the Altair 8800 from MITS are single-user minicomputer systems. They provide no facilities for immediate execution of arithmetic computations, do not support user-machine dialogue via special purpose keys and do not use magnetic tapes for data storage. Nevertheless, some of their features show that they may be strong competitors to the maxi-calculators.

2.2.1 Classic

The Classic has been on the market since 1975. It is a minicomputer system which uses a subset of Digital's OS/8 (Operating System/8) and provides compilers for BASIC and FORTRAN IV.

A Classic system includes:

-a keyboard arranged in a conventional typewriter format;
-a dual flexible disk unit for fast, large data storage (500K bytes);
-a CRT display of 12 lines of 80 characters per line;
-a CPU of 32 K bytes memory (24K bytes are available for user program area);
-a slow electrolytic copier, mounted on the side of the visual display unit.

This configuration, including BASIC, sells for $8,900. DEC also offers a card reader and a large assortment of educational courseware packages.

The Classic offers very little support for interaction with the system, so its operator must be expert in using the command language. (See (5)).

2.2.2 Altair 8800

The Altair 8800 went on sale in January, 1975. It is a modular computer system and each feature can be purchased separately as a kit or already assembled.

A configuration which is comparable to the maxicalculators might look like this:

-a terminal with 32 character display and teletype-like keyboard with special function keys (assembled $920)
-a single floppy disk with 300K bytes of storage (assembled $1,980)
-12K bytes dynamic memory (assembled $825)
-an I/O interface (assembled $138)
-Altair Extended BASIC ($150)
-Altair assembler, text editor, system monitor ($30)
-Altair disk operating system ($150)

This system, which is a more powerful computer than any other system described here,* costs $4,193.

A line printer for $1,975 is also available. A card reader might be purchased from another vendor.

Using this Altair 8800 system seems to require that its operators possess great knowledge about computers. As it was not possible for us to gain experience with this system it is not discussed in detail in this paper.

*The MCM/700 is an exception to this statement if APL, virtual memory and communication and miterface capabilities are regarded as more important than assembler, BASIC, text editor and large memory of the Altair.

2.3 Summary

This introductory discussion of maxicalculators and minicomputers suggests that two maxicalculator systems seem well-adapted to serve as computers for the whole school. (See (6)). In the remainder of this paper, then, only the HP9830 and the Wang 2200 will be discussed at length. The other systems will be considered only if some of their unique properties are relevant.

3. Maxicalculators for the whole school

Some guidelines and evaluative criteria for educational computer systems have been developed (see (5) and (7)) but at this time no instrument for comparison of computers for the whole school seems to exist. A number of criteria especially suited for the evaluation of maxicalculators for use in the whole school will be given in Section 3.2.

The primary criteria will not be size, speed, cost, or power of a maxicalculator, but will be considerations of the interaction between the machine and its user while he is using it. We therefore treat this interaction before discussing the criteria.

3.1 The user-calculator interaction

3.1.1 Uses of computers in schools

In many secondary schools medium size computers are used for administrative purposes. Smaller computers and maxicalculators are mostly used for various types of instructional applications of computers or "IAC" (see (4) and (8)) including computer guided study (9) and computer-managed instruction; and also for teaching computer science and for small administrative jobs.

3.1.2 Users of computers in schools

In most schools teachers write or purchase the majority of programs which are then used by the students, but students also write their own programs for instructional applications. Some students get deeply involved with the computer, others just want to use it passively. Administrators use computers for a great variety of jobs.

3.1.3 The components of computers

An educational computer combines hardware, software, courseware, and support by the vendor. All of these components play a large role in the interaction between machine and user; all of them have to be considered in an evaluation of maxicalculators.

3.2 Criteria

The following criteria give rough ideas about what should be taken into account in the interaction between user and machine. A second paper (see (10)) will present detailed evaluation questions about the features of the maxicalculators. The answers to these questions by a given school provide a comparative evaluation of the maxicalculators, as seen by that school.

3.2.1 Terminal

The terminal of a maxicalculator consists of the keyboard, the screen, the storage system, and the central processing unit. The keyboard of a maxicalculator can give its user great support in the interaction with the machine. Special calculator keys and BASIC statements keys can make calculating and programming easy. Beginning students especially will appreciate well-defined control keys.

An important criterion will be whether a CRT is necessary for good interaction or whether a one-line display has more advantages. Rapid displaying, high speed scanning, and scrolling features can make long dialogues pleasant. A bright image, large characters, and a reliable cursor are as important for experts as for beginners. Paging and selective hole and erase (available on the Wang CRT display) allow for great variety of presentation of data on the screen in instructional or administrative application.

If large administrative programs are to be run with the greatest efficiency on a maxicalculator a disk drive will be a must, but for most other applications, students and teachers will be highly satisfied with magnetic tape cassettes, especially if the maxicalculator allows fast access to files, provides a sufficient set of tape commands, and offers a means for read or copy security.

The size of the memory purchased initially will be a question of money. But there will soon be complaints about shortage of memory, so it is important to check the cost of additional memory in advance.

It will have a strong positive influence on the satisfaction of teachers and students if the maxicalculator is compact, easily portable, rugged, and, above all, quiet.

3.2.2 Software

It might not be an important question for a student whether the BASIC language is wired-in or loaded into memory, but he will soon feel the difference between a compiled and an interpreted language. The interpreter provides an error message after each line on which an error occurs whereas the compiler delivers a list of error messages only after the student has tried to run the program. If entire classes use the computer for instructional applications, a batch mode is a necessity and should be provided by a suitable ROM.

Great advantages of maxicalculators over minicomputers are key commands instead of a command language, a direct calculation mode, and user-defined function keys. These features make interaction with the machine much easier for the user.

The size of the CPU and of extensions to its memory set limits to the length of a program. Therefore external data files with a chaining feature are necessary.

A source of great dissatisfaction may be the error diagnosing and debugging facilities. If a user has to enter entire lines again, even if it is only in calculation mode, he will easily become hypercritical. A helpful editing mode and a powerful interrupt facility makes interaction smoother.

The capabilities of the BASIC version that is offered may have influence on user satisfaction, too, but the slight differences between the BASIC dialects will only be detected by the few computer experts at a school, not by the majority of the students and teachers.

Benchmark instructional programs are useful to measure the speed of a computer and its suitability for different instructional uses of its input and output devices (printers, displays, cassette tapes, and card readers). For some of these uses, waiting for input or for more cards may take much more time than the computing itself, and computing speed may therefore be unimportant. Benchmarks are also needed for measuring the speed of administrative programs and the efficiency of the different file handling systems in different maxicalculator systems.

3.2.3 Hard copy

The first question about the hard copy will be whether the hard copy itself is essential for the use of the system. The Wang 2200 may run effectively without a printout whereas the HP9830 cannot run usefully for many educational uses without a printer to give hard copy. Several criteria must be considered before the decision is made to get a given printer. Is the speed of a typewriter-like printer sufficient or is only a high-speed line-printer adequate? The decision for the cheaper typewriter can cause users great frustration. The cost of thermal printer paper may eliminate this printer from consideration for some schools, but its quietness will be appreciated by all users.

3.2.4 Other peripherals

An additional magnetic tape cartridge or a disk drive will be considered a necessity by administrative users, whereas teachers will ask for a TV-screen or a marked/punched card reader. Mark sense readers must be checked out very carefully before a decision can be made, because not all of them seem to work reliably, and some need a special ink instead of a soft lead pencil.

3.2.5 Support

A factor that cannot be overestimated is the support offered by the maxicalculator vendor. The calculator textbooks, self-instructional programs, and application material supplied are a great help to the teacher. A well-developed user group, sales and support staff familiar with the education market, and a reliable maintenance system will contribute to the satisfaction of administrators, teachers, and students.

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